BELLCOMM, INC.

SUBJECT: Summary of the Data Links From the Apollo Applications Spacecraft to the Manned Space Flight Network for AAP Missions 1-4 - Case 600-2

DATE: June 30, 1967

FROM: R. L. Selden

ABSTRACT

A summary is presented of the spacecraft to ground data links currently planned for the Apollo Applications spacecraft that are to be used in Apollo Applications missions 1-4. Also presented is a summary of the capability within the Manned Space Flight Network to receive and process data. The space vehicle configuration of mission AAP 1/2 has the capability of transmitting six telemetry links to the MSFN and the configuration planned for the AAP 3/4 mission the capability of transmitting nine. This is contrasted with the capability of the network to process operationally required data from only three links (four at Bermuda, Antigua and Grand Bahama Island). Some possible combinations of these links are suggested that would result in a reduction in the number of links to be transmitted. These combinations include: 1) integrating the LM and Apollo Telescope Mount data systems and 2) provide a common system for the orbital workshop-airlock module and multiple docking adapter.

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MEMORANDUM FOR FILE

This memorandum summarizes the present planning for the data links (telemetry and television) that will be used to transmit data from the Apollo Applications (AAP) spacecraft to the Manned Space Flight Network (MSFN) for the AAP missions 1-4. Only the spacecraft to MSFN data links are considered here because, due to their number and the types of data on each, they represent a potential operational problem and/or impact on the implementation of the MSFN and possibly the Mission Control Center at Houston (MCC-H).

Table I of this memorandum summarizes the rf links that are currently planned that are to carry vehicle status and experiment data from the spacecraft modules to the MSFN. These links are to be implemented on the modules listed, which are elements of AAP missions 1-4. A more detailed discussion of the complete communications systems of all mission elements will be given in a forthcoming Bellcomm Technical Memorandum, as well as a brief description of each mission.*

The data transmitted over the links delineated in Table I can, in general, be placed in four categories, all of which could be required to successfully conduct the mission. These categories are:

(1) Real-time status data on the space vehicle modules and astronauts.

(2) Recorded status data on the space vehicle elements and astronauts which can be used to indicate past performance when the spacecraft was not in view of a station within the MSFN (trend data).

(3) Experiment data either real-time when the experiment is active and the cluster is over a station of the MSFN or data recorded on board a spacecraft prior to a pass over a MSFN station.

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*A. G. Weygand, "Description of the Communications and Tracking Systems of the Space Vehicle for Mission AAP-1A and for Missions AAP 1-4," Bellcomm, Inc., Technical Memorandum, to be published.

(4) Real-time or recorded status data of the various experiments to be flown on these missions.

Operational data will be required during the first four missions to insure crew safety and mission success. Detailed planning for these missions is not sufficiently along at this time so that the required operational data can be specified. It is expected, however, that since one of the objectives of the AAP program is to conduct useful experiments in space with existing hardware, some quantity of experiment data may be required to insure successful completion of these experiments. These data will be required along with the normal spacecraft status and astronaut biomedical data.

The design philosophy invoked for the spacecraft data systems, to this point, has been one of minimal interface and essentially independent systems in each module (i.e. the CSM, LM, ATM, OWS, AM). While this approach minimizes design problems (with the possible exception of antenna systems) and spacecraft-to-spacecraft and center-to-center interfaces, it tends to maximize the number of links that are radiated to the MSFN. This is shown by summarizing the number of data links by mission. From Table I it can be seen that during the AAP-1/2 mission, six data links can be transmitted simultaneously to the MSFN (4-VHF and 2-S-Band). During the AAP-3/4 mission, nine links are possible (6-VHF and 3-S-Band). This number of telemetry channels is in excess of the ground station's capability to process the data if data from more than three links is required simultaneously. Table II summarizes the capability of the various MSFN stations, including the ships, to receive and process data. Table II shows that in general no problem exists in receiving this multiplicity of rf carriers. Perusal, however, of the PCM decommutation capability shows that all stations lack the capability to process the data if operational data is required from more than three of four links. It is well to point out that each of the decommutation stations in the network have the capability of processing from 500,000 to 1,000,000 bits of data per second, from one bit stream at a time. Additionally, the remote site data processors for telemetry have the capability of accepting data from up to four decoms simultaneously, with software redesign Table II also shows that the data (and voice) from the stations of the MSFN is transmitted to MCC-H via six voice/data circuits from each site. Normally, no more than three of these six are available to transmit telemetry data (at a rate of 2,400 bits per second). This limited capacity could also become an operational constraint.

It appears some consideration should be given to the spacecraft data system design to avoid a high cost augmentation

to the MSFN. One decommutation station at any of the MSFN stations has the capability to process all of the data from the full cluster mission (AAP 3/4) if it were received in one high speed bit stream. From this, it is obvious that any consolidation possible in the spacecraft could alleviate the ground data flow problem. Several logical possibilities exist that should be evaluated. In fact, some are being investigated at present. Logical combinations would seem to be the following.

(1) Combine the data from the LM and that of the real-time system of the ATM rack. This combination is being investigated at present. An extension of this combination might allow the recorded data to be combined with the real-time system.

(2) Provide a common system(s) in the Orbital Workshop/ Airlock/Multiple Docking Adapter combination. This seems particularly attractive (except for the intercenter interfaces involved) because all three of these modules are mounted together at launch. Additionally, present planning is to prewire wherever possible. Again an extension of this combination might be in the marriage of the real-time and tape recorder playback systems.

Undoubtedly systems such as those described above, particularly in the combination of real-time and playback data in an integrated system would take some development. Investigation of these, however, might show that this approach is more cost effective than augmenting the MSFN. An alternative to this would be a mission design that would not require any recorded (on board the spacecraft) data in real-time, but rather in "near real-time," i.e., immediately subsequent to the space vehicle's passage over a station. Regardless of the "reimplementation" affected at the present time, it appears that some control is required over the total telemetry and rf systems that are implemented in the future.

R. L. Selden

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Attachments
Tables I and II

Table I

APOLLO APPLICATIONS - SPACECRAFT DOWN LINKS (DATA)

SPACECRAFT	TRANSMITTER FREQUENCY	MODULATION TYPE	INFORMATION
S-IVB	258.5 MHz[1]	FM	PCM Real Time 72.0 kB/S
IU	250.7 MHz[1]	FM	FM/FM (IRIG) Real Time
	255.1 MHz[1]	FM	PCM Real Time 72/0 kB/S
Orbital Workshop	VHF-1[2,6]	FM	PCM Real Time ?
	VHF-2[2]	FM	FM/FM (Data Playback)
Air Lock Module	230.4 MHz	FM	PCM or FM/FM[3,5] PCM-51.2 kB/S (Real Time) or 112.64 kB/S (Data Playback)
	246.3 MHz	FM	PCM or FM/FM[3,5]
CSM	2287.5 MHz	PM	FM/PM Real Time Voice
			PSK/PM Real Time Telemetry 51.2 kB/S or 1.6 kB/S
			PN/PM Ranging
	2272.5 MHz	FM	Television or Playback Voice and Telemetry
LM	2282.5 MHz[4]	PM	FM/PM Real Time Voice and Biomedical Data
			PSK/PM Real Time Telemetry 51.2 kB/S or 1.6 kB/S
			PN/PM Ranging

Table I (continued)

APOLLO APPLICATIONS - SPACECRAFT DOWN LINKS (DATA)

SPACECRAFT	TRANSMITTER FREQUENCY	MODULATION TYPE	INFORMATION	
LM	2282.5 MHz[4]	FM	Television	
			FM/PM Real Time Voice and Biomedical Data	
			PSK/PM Real Time Telemetry	51.2 kB/S or 1.6 kB/S
Apollo Telescope Mount	231.9 MHz	FM	PCM Recorded or Real[5] Time Telemetry[5]	72.0 kB/S
	235.0 MHz	FM	PCM	72.0 kB/S

Notes:

1. These links do not require support 7.5 hours after orbital insertion
2. These links are <u>proposed</u> to handle MDA & OWS housekeeping (VHF-1) and experiment data (VAF-2)
3. FM/FM data is playback data recorded during biomedical experiments in the OWS
4. LM S-Band system operates either in a PM mode or an FM mode (not simultaneously)
5. Modulation may be switched from one transmitter to the other
6. The data on this link is primarily OWS status data and may also appear on the real-time link from the air lock.

Table II

MSFN STATION CAPABILITY

STATION	TELEMETRY RECEPTION					PCM DECOMMUTATION	COMMUNICATIONS		
	Unified S-Band		VHF		S-Band		TV	V/D	COMSAT
	PM	FM	Dual	Single	FM Tele.				
Ascension	1 to 4	0 to 2	4	8	1	3		6	X
Carnarvon	1 to 4	0 to 2	4	12	1	3		6	X
Guam	1 to 4	0 to 2	4	12	1	3		6	
Hawaii	1 to 4	0 to 2	4	12	1	3		6	
Merritt Island	1 to 4	0 to 2	4	8	1	3	1	6	
Antigua	1 or 2	0 or 1	0	6	1	4		7	
Bermuda	1 or 2	0 or 1	15	4	1	4		8	
Canary Island	1 or 2	0 or 1	4	12	1	3		6	X
Guaymas	1 or 2	0 or 1	4	12	1	3		6	
Texas	1 or 2	0 or 1	4	12	1	3		6	
Grand Bahama	1 or 2	0 or 1	4	6	1	4		7	
Goldstone	2 to 8	0 to 4	0	0	0	3	1	6	
Canberra	2 to 8	0 to 4	0	0	0	3		6	
Madrid	2 to 8	0 to 4	0	0	0	3	1	6	X
Vanguard	1 to 4	0 to 2	0	20	0	3		6	X
Redstone	1 to 4	0 to 2	0	12	0	3		6	X
Mercury	1 to 4	0 to 2	0	12	0	3		6	X
Watertown	1 or 2	0 or 1	0	12	0	1		1	
Huntsville	1 or 2	0 to 1	0	12	0	2		1	

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